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TITLE SUMMARY FROM WORKING GROUP ON NONINTERCEPTIVE DIAGNOSTICS

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OVERVIEW

The working group for noninterceptive diagnostics spent much of its time comparing diagnostic techniques from different fields and their possible application to high-power injectors. The group was composed of T. Fessenden, R. Fisher, D. Schneider and D. Chamberlin and thus included backgrounds from electron beam diagnostics, fusion power diagnostics, cw ion source and transport design, and ion beam diagnostics. The probability of success for adapting techniques from these different areas is quite difficult to judge, short of a detailed examination of each application. Unexpected flaws or unforeseen noise sources can eliminate an idea that would otherwise appear promising. The following is a report of the several ideas that were discussed, with an indication of those ideas most likely to succeed if implemented.

Attention was placed on wall current monitors, which measure return currents in the beam pipe wall and offer both positional information from separated current paths and total current information from the sum. These have worked well in other applications.[1] The electronics components associated with electromagnetic pickups may be expected to perform well at frequencies up to a hundred megahertz, but both performance and "off-the-shelf" availability fall off rapidly as frequency requirements increase toward and past a gigahertz. Similar information might be obtained from coupling a ferrite-loaded cavity to the beam pipe although this concept works only for bunched beam after an rf structure.

Optical sensing of beam-induced light is barely in the first stages of its applications. Several extensions of this technique immediately suggest themselves. The absolute level of light could provide more information on conditions in the region occupied by beam, and the ion plasma background could be monitored. We postulated that even he electron flows in the dc portion of beamline might create light. In general, there is more to be accomplished and gained from studying the physics of gas excitation and subsequent light emission processes. One could perturb the gas species and pressure. Information about ion velocity may be obtainable. Choosing specific lines with filters should give more specific data and drastically reduce light backgrounds from halo beam impingement on surrounding structures.

Beam voltage potential measurements in the dc transport line are of interest, not only for their relevance to ion source conditions and performance but also in the study of neutralization of the primary ion beam's space charge. The ideas suggested for poten-

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tial studies included adding impurity background gas, photoionization, tracking of ion trajectories by dye laser, and fast emissive probes. Electrons may be driven from the beam region with velocities varying as that potential. A further source of ideas and techniques is given in Ref. 2.

A noticeable lack in present capabilities is in the ability to effectively measure beam halo. The optical technique may be able to see the beam edges by the difficult task of occluding the beam core with a light stop and then at the same time achieving sufficient dynamic working range in the tails. The several possible variations of a crossed beam technology were noted. The ion beam could be intercepted by a puff of gas or on a lithium curtain. It appears that the cross sections are too low to observe any attenuation of an intercepting optical radiation, but perhaps a properly chosen electron beam could be used. A calculation of particle density shows the quite sparse ions of the beam to be passing through a much denser (by several orders of magnitude) background gas.

The service role of beam diagnostics was acknowledged by pointing out the usual evolution of a beam sensing device from an experimental version, to a prototype, and finally to production. The importance of a measurement may vary in that the first reliable data may indicate proper beam conditions and the measurement may be dropped. But the diagnostic technical capability and skills seems to be called upon for more and more detailed information; thus, the development effort must be apportioned to support the continuation of a capable team, and the continuing team must keep its publication record up to date. The present status is also available in Ref. 3.

Outlined below are summarized conclusions reached by the working group.

CURRENT TECHNOLOGY STATUS

- Interceptive techniques are well established for use on less-intense beams
- Noninterceptive optics techniques are working well for measuring the profiles of high-perveance, dc or cw beams
- Noninterceptive techniques are expected to evolve rapidly
- Electromagnetic probes operate well at 80 MHz, but the lack of suitable electronics components will make the task more difficult at higher frequencies
- Basically, the present needs are being met

MAJOR PROBLEMS WITH CURRENT TECHNOLOGY

- New non-interceptive work has been done by a small community
- Interceptive techniques are generally not usable
- High power density in the beam makes fast, high-quality diagnostics even more vital
- Even beam halos are damaging to beamline components

  - They are difficult to measure because they are so much less intense than the core regions, thus calling for large dynamic range in the sensor
  - They are difficult to simulate because their formation and behavior is not understood and is poorly measured
- There has been limited technology development for dc and cw beams
- Often the beamline design offers only limited space for equipment
- Computed parameters require processing time
- Absolute calibration of current is difficult without calorimetric measures

IMPROVEMENTS TO PRESENT BEAM DIAGNOSITCS

There is a need for the following:

- Higher frequency response
- Improved resolution
- More real-time information
- Extended dynamic range
  - Sensors that are sensitive to halo
- Smaller sensors and instrument packages
- Repackaged, better engineered components
  - Better reliability, data reproducibility
- Enhanced (array) processing

NEW IDEAS

- Beam potential measurements are of great interest for studies of space-charge neutralization
- Absolute excitation light measurements
  - Electron flows create light
- Electron imaging
- Current monitor
  - Wall current
  - Loaded cavity

1. T. J. Fessenden, B. W. Stallard and G. G. Berg, "Beam Current and Position Monitor for the Astron Accelerator," Rev. Sci. Instrum. 43 (12), 1789 (1972).

2. J. Borer and R. Jung, "Diagnostics," CERN/LEP-BI/84/14 Geneva, October 1984.

3. D. D. Chamberlin, "Noninterceptive Beam Diagnostics," Los Alamos National Laboratory document LA-UR-85-2941.